

# World Energy Consumption

*The IEO2002 projections indicate continued growth in world energy use, including large increases for the developing economies of Asia and South America. Energy resources are thought to be adequate to support the growth expected through 2020.*

The *International Energy Outlook 2002 (IEO2002)* presents the Energy Information Administration (EIA) outlook for world energy markets to 2020. Current trends in world energy markets are discussed in this chapter, followed by a presentation of the *IEO2002* projections for energy consumption by primary energy source and for carbon emissions by fossil fuel. Uncertainty in the forecast is highlighted by an examination of alternative assumptions about economic growth and their impacts on the *IEO2002* projections and how future energy intensity trends could influence the reference case projections. The chapter ends with a comparison of the *IEO2002* projections with forecasts available from other organizations.

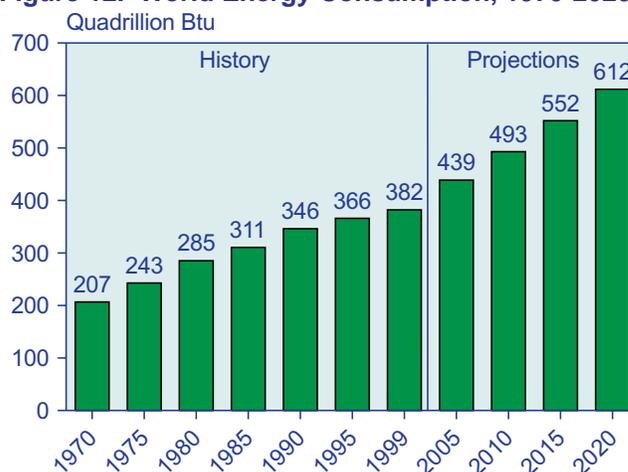
## Current Trends in World Energy Demand

Between 1999 and 2020, total world energy use is projected to grow from 382 quadrillion British thermal units (Btu) to 612 quadrillion Btu (Figure 12 and Table 1)—a 60-percent increase—in the *IEO2002* reference case projection. Energy markets in 2001 were affected by a host of developments and events, including high world oil prices that continued from 2000 into the first half of the year and then weakened substantially toward the end of the year; a global economic slowdown led by the United States; and the aftermath of the terrorist attacks on the United States on September 11, 2001.

For much of 2001, world oil prices remained in the news, with prices within or slightly above the price range of

\$22 to \$28 per barrel that the Organization of Petroleum Exporting Countries (OPEC) considers optimal (Figure 13). After September 11, oil prices initially spiked, but a substantial lowering of demand in the weeks and months that followed made it difficult for OPEC to hold prices much above the \$22 per barrel level [1]. An OPEC meeting on September 26-27 did not result in an anticipated oil production cut to shore up prices, which were beginning to fall even before the terrorist attacks.

**Figure 12. World Energy Consumption, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

**Table 1. World Energy Consumption and Carbon Dioxide Emissions by Region, 1990-2020**

Region	Energy Consumption (Quadrillion Btu)				Carbon Dioxide Emissions (Million Metric Tons Carbon Equivalent)			
	1990	1999	2010	2020	1990	1999	2010	2020
<b>Industrialized Countries</b> . . . . .	182.7	209.7	246.6	277.8	2,849	3,129	3,692	4,169
<b>EE/FSU</b> . . . . .	76.3	50.4	61.8	73.4	1,337	810	978	1,139
<b>Developing Countries</b> . . . . .	87.2	121.8	184.1	260.3	1,641	2,158	3,241	4,542
Asia . . . . .	51.0	70.9	113.9	162.2	1,053	1,361	2,139	3,017
Middle East . . . . .	13.1	19.3	26.3	34.8	231	330	439	566
Africa . . . . .	9.3	11.8	15.7	20.3	179	218	287	365
Central and South America . . . . .	13.7	19.8	28.3	43.1	178	249	377	595
<b>Total World</b> . . . . .	<b>346.2</b>	<b>381.9</b>	<b>492.6</b>	<b>611.5</b>	<b>5,827</b>	<b>6,097</b>	<b>7,910</b>	<b>9,850</b>

Sources: **1990 and 1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

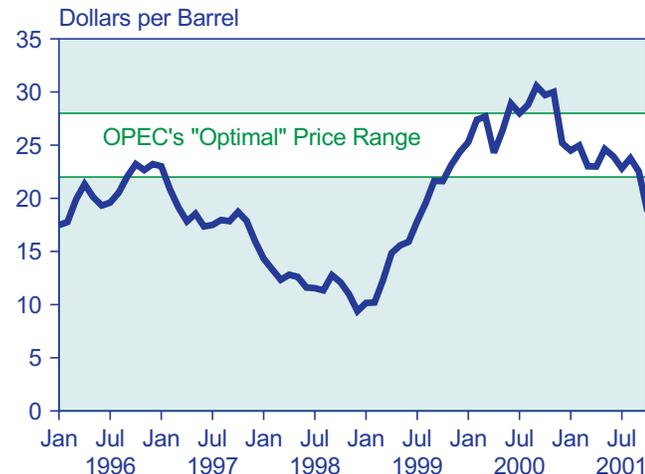
The organization was concerned about maintaining stable oil markets after the attacks.

OPEC experienced some difficulties in trying to maintain its desired price band both before and after the September attacks. The slowing U.S. economy had already reduced the demand for oil, and the cartel reduced oil production quotas by a combined 3.5 million barrels per day in three separate instances before the terrorist attacks [2]. In mid-November 2001, the OPEC member nations met again to discuss ways to boost sagging oil prices that had fallen to as low as \$18 per barrel and had dipped even lower in day trading. OPEC announced it would cut production by another 1.5 million barrels per day, beginning in January 2002, but only on condition that key non-OPEC oil suppliers, Mexico, Oman, Russia, and Norway, would also cut production. Angola and Kazakhstan also indicated a willingness to consider cutting exports [3]. OPEC wanted non-OPEC suppliers to remove a combined 500,000 barrels per day from the market.

Russia proved to be the single holdout against OPEC's demands for a production cutback, initially offering to cut only 50,000 barrels per day in production [4]. OPEC had hoped for a Russian cut of between 100,000 to 150,000 barrels per day. Some analysts thought there could be a price war in early 2002, with Saudi Arabia and Russia—the two largest oil producers in the world—vying for market share. Finally, on December 5, Russia announced that it would cut its oil exports by some 5 percent, or the 150,000 barrels per day that OPEC had requested, beginning in January 2002 [5].

The degree of compliance among the OPEC and non-OPEC members who struck the December 2001

**Figure 13. Refiner Acquisition Cost of Imported Crude Oil, 1996-2001**



Source: Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(2002/01) (Washington, DC, January 2002).

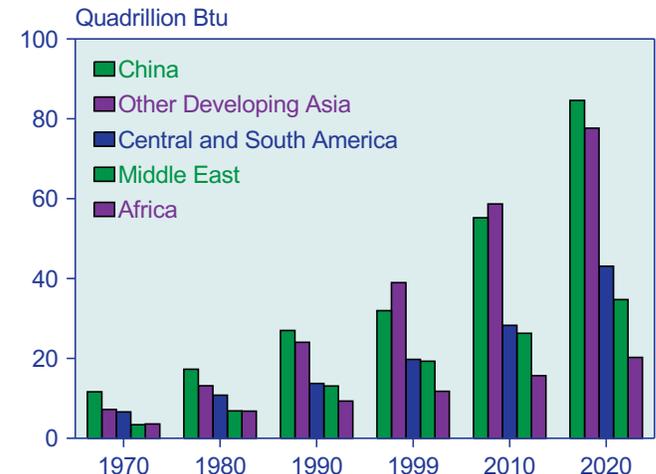
agreement remained uncertain as *IEO2002* went to print. The OPEC member countries (not including Iraq) succeeded in reducing their oil production by an estimated 1 million barrels per day in January 2002 [6]. Non-OPEC members had mixed success, however, in meeting their commitments to reduce oil production. The future for supply cuts is also uncertain. Norway has announced that it will continue its pledged supply cut at least until the end of June 2002, but Russia has not yet decided whether to extend its pledge to cut 150,000 barrels per day for a second quarter [7]. OPEC has indicated that its cuts may remain in place until 2003 if demand and prices remain weak.

With the terrorist attacks and the ensuing war launched in Afghanistan against the Al Qaeda terrorist network and the ruling Taliban regime, the short-term outlook for world economic and energy growth is fraught with even more uncertainty than normal. The mid-term outlook will also be affected by developments in the American-led anti-terrorist actions, an outlook that is difficult to assess in early 2002.

Nevertheless, *IEO2002* expects that the regional trends underlying the reference case in past editions of this report will not be substantially altered. The *IEO2002* reference case forecast still shows the fastest pace of growth in energy demand over the next two decades in the developing world, with developing Asia and Central and South America leading the way (Figure 14) as the economies in the two regions continue to develop and their consuming patterns increasingly come to resemble those of the industrialized world.

Developing countries as a whole are projected to account for 60 percent of the increment in total energy

**Figure 14. Energy Consumption in the Developing World by Region, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, *World Energy Projection System* (2002).

use over the projection period, compared with the industrialized world's 30 percent (Figure 15). The emerging, transitional economies of Eastern Europe and the former Soviet Union (EE/FSU) account for the remainder.

Even before the events of September 11, the U.S. economy was showing signs of slipping, and many analysts believe the attacks in September virtually ensured that the country would be pushed into recession. In fact, the National Bureau of Economic Research declared in late November that a recession had begun in the United States as early as March 2001 [8]. Recession in the United States clearly has implications for international markets and, in turn, the demand for energy worldwide. Slowing markets in the United States mean a lowered demand for imports. The technology sector, spurred by a spate of computer upgrades because of Y2K-related fears in 1999, had slowed dramatically by 2001, resulting in slower economic growth for many Asian, technology-exporting countries, such as South Korea and Taiwan, which provide much of the computer equipment for the United States and other parts of the industrialized world [9].

The negative impact of the slowing U.S. economy on the markets of the developing world is expected to be made even worse because of the persistent Japanese recession and a slowing of the economies of Western Europe. With virtually all of the industrialized world slowing, or already in full recession, it will be difficult for the developing world to resist an economic turndown as well. Japan's economy was stagnant or in decline for much of 2001, and many analysts feel that the country is in yet another of a series of recessions that have plagued it for

the past several years. Deflation continues to be problematic for Japan, as it has been since 1996, and consumers are reluctant to spend while the true value of their assumed debt continues to expand [10]. Thus far, Prime Minister Koizumi's efforts to shift government fiscal policy away from public works projects and toward economic reforms have not been successful.

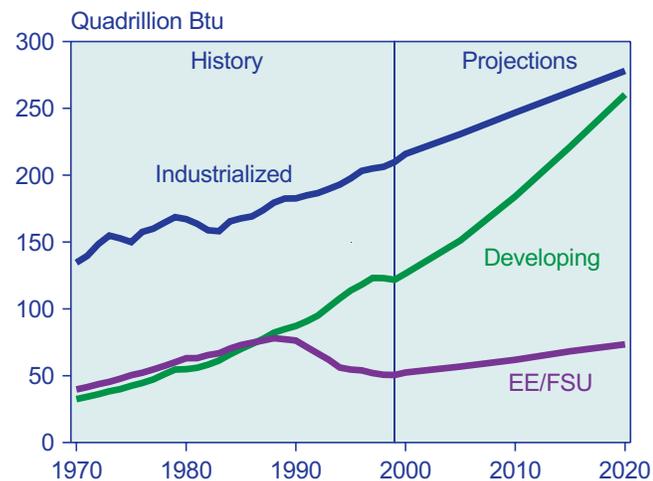
The Western European economies also began to show signs of recession or of economic slowdown in 2001. The European Central Bank (ECB) resisted cutting interest rates for the first quarter of 2001, but as the slowing economic performance became clear, the Governing Council agreed to cut interest rates by a total of 150 basis points between May and November in four separate instances. Two of the cuts were made after September 11, and the ECB Governing Council stated that its cut on September 17 was being made because the terrorist acts on the United States would be likely to "weigh adversely on confidence in the euro arena, reducing the short-term outlook for domestic growth" and to increase inflationary risks [11].

In Germany, Western Europe's largest economy, gross domestic product (GDP) growth fell to 0.8 percent in 2001, from 3.2 percent in 2000. Even before the September 11 terrorist attacks, the German economy showed signs of weakening, with year-to-year growth slowing from 1.8 percent in the first quarter of 2001 to 0.6 percent in the second quarter and 0.3 percent in the third [12]. Analysts speculated that the country would soon be in a recession. Tax cuts in 2001 helped to soften the impact of Germany's slowing economy in 2001, and the government is considering moving up the time frame for implementing further cuts originally scheduled for the period 2003 to 2005, in an attempt to stimulate economic recovery.

Other countries in Western Europe were also showing signs of weakening. Tax cuts helped to boost consumer spending in France in the first part of 2001, but weakening manufacturing output related to lowered export demand after the terrorist attacks in the United States is expected to make it difficult for France to maintain its pace of economic growth into 2002 [13]. Modest growth was reported in Italy and the United Kingdom, but export growth slowed substantially after September in both countries [14].

Developing Asia (outside of China and India) is particularly vulnerable to fluctuations in the economies of the industrialized world, because many Asian countries largely depend on revenues from exports to industrialized countries. In particular, the United States is the largest export market for most Asian countries, and the U.S. recession has already had adverse impacts on the Asian markets. Singapore and Taiwan have suffered income contractions, and Hong Kong and Malaysia are near

**Figure 15. Energy Consumption by Region, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

recession, with South Korea, Thailand, and Indonesia reporting slowing economic growth [15].

Exports from the developing Asian countries have uniformly declined. The demand for electronic technologies has not rebounded from the declines in 2000, which has hurt the economies of technology producers South Korea, Taiwan, Singapore, and Malaysia, resulting in a 20-percent decline in exports at the end of 2001. Even China and Indonesia—countries that are less dependent on technology-oriented exports—have suffered from the global economic slowdown in 2001. China's exports grew by 4 percent in the third quarter of 2001, compared with 25 percent during the same period in 2000. In Indonesia, exports declined by 10 percent in the third quarter of 2001, compared with 25-percent growth in the third quarter of 2000.

Not surprisingly, the terrorist attacks have made the economic situation in developing Asia even worse. With expectations that the U.S. recession will be prolonged and growth in exports will not revive quickly, the economic slowdown in developing Asia is expected to continue well into 2002. Moreover, international tensions are likely to have an adverse impact on tourism which will further harm the economies of Hong Kong, Singapore, and Thailand, where tourism accounts for more than 6 percent of GDP in each country [16]. Amidst worries of prolonged recessions among the developing Asian nations, domestic consumer demand has weakened as well, adding to the problems of the regional economies.

China has fared better than its neighbors, mostly because of the large state-sector investment expansion and stable private-sector consumption growth. Between 1998 and 2000, the Chinese government issued \$43 billion worth of special bonds to finance investment in the public infrastructure and indicated that it may issue another \$18 billion in 2001 and 2002 to ensure that economic growth continues [17]. China's GDP increased by 7.6 percent in the first three quarters of 2001, and it is expected to slip only slightly in 2002, to 7.2 percent. That said, China's accession into the World Trade Organization at the end of 2001 is expected to result in a short-term adverse impact on the economy, with fears that foreign competition may test China's often inefficient state-owned firms [18].

India has also thus far weathered the global economic slowdown fairly well, reporting higher than expected increments in income in 2001. At present, there are increasing signs of a slowdown in India as the growth in exports continues to decline and consumer spending also begins to falter. Passenger car sales in India fell by 22 percent between September 2000 and September 2001, and sales of commercial vehicles fell by 6 percent over the same time frame [19].

The slowdown in the industrialized countries' economies has affected the performance of economies in Central and South America. However, in two of the larger economies of the region, Brazil and Argentina, other circumstances have exacerbated the short-term economic risk. In Brazil, the largest economy of South America and the world's sixth largest economy, a persistent drought continued in 2001, leading to reduced industrial output as the government imposed a 20-percent cut in power use as part of its rationing program, in an effort to avoid blackouts [20]. Brazil's plan to diversify the electricity mix of the country by increasing thermal generation, particularly in terms of natural-gas-fired capacity, took on more urgency in 2001, partly in response to the ongoing threat of drought in a country that normally generates more than 80 percent of its electricity from hydropower. Reservoir levels fell 28 percent below capacity in key consuming regions of the country in the fall of 2001.

In 2001, the vulnerability of Brazil's electricity supply, in consort with the slowing industrial economies, led to reduced foreign investment, which had been a key contributor to the success of the nation's economy in 2000. With substantial support of foreign direct investment, the Brazilian government was able to handle a large current account deficit and was given a fair amount of latitude in the way it conducted monetary policy [21]. The central bank of Brazil increased interest rates in an attempt to limit the depreciation of the Brazilian real, but Brazil's benchmark interest rate (known as Selic) reached 19 percent in early 2002. With substantially lower exports in the face of the U.S. and world economic slowdown that began in 2001, growth in Brazil's GDP was only 1.5 percent in 2001 and is expected to be only 1.9 percent in 2002, compared with 4.5 percent in 2000 [22].

Argentina is another key economy of the Central and South America region, but it has also experienced several difficult economic years. When the Brazilian real was devalued in 1999, the close economic relationship between the two countries resulted in recessionary problems for the U.S. dollar-pegged Argentine currency. In fact, the country remained in the recession it has now been struggling with for more than 4 years. In early September 2001, the International Monetary Fund (IMF) lent assistance to Argentina, approving an increase of the country's available credit to \$22 billion in an attempt to stabilize the economy and to help attract investment and improve output [23]. Subsequently, however, the IMF decided to withhold some \$1.26 billion in payments to Argentina in December when it became concerned that the country had not implemented sufficient austerity measures [24].

The Argentine financial situation deteriorated so much that President de la Rúa resigned in December 2001, and three new presidents were sworn in and resigned in

quick succession until Eduardo Duhalde took the office [25]. Duhalde announced a devaluation of the Argentine peso which would no longer be pegged to the U.S. dollar. The country also defaulted on a \$28 million payment on a 2007 Italian lira bond—one of the largest defaults on record. There are worries that the default will make it nearly impossible to attract foreign investment into the country and that the new government may be turning away from the free-market policies it has implemented over the past decade in favor of more government control.

One bright spot among the economies of the world is the positive economic growth that continues in the countries of the former Soviet Union (FSU). In 2000, high world oil prices and a devalued ruble helped Russia—the region’s largest economy—post its strongest year of economic growth, 8.3 percent, since the dissolution of the Soviet regime [26]. With the devaluation of the ruble making it difficult for consumers in the former Soviet republics to purchase imported products, domestic manufacturers began to increase production strongly. As the ruble regained value in 2001, the manufacturing sector slowed somewhat (as imported goods once again were able to compete with domestic goods), but relatively high world oil prices in the beginning of the year helped to keep economic growth positive in Russia, and its GDP grew by 5.3 percent in 2001.

The other FSU republics benefited from the improving Russian economy. In 2000, Ukraine posted its first increase in GDP since 1989, 5.8 percent, and an even stronger growth rate of 8.5 percent followed in 2001 [27, 28]. The country is a net importer of oil, and the high world oil prices did not benefit the Ukrainian economy. Instead, fiscal reform and strong growth in industrial output, construction activity, agriculture, and exports, along with fast-paced growth in domestic consumption and investment, helped to fuel Ukraine’s economic growth. The government has managed to balance the state budget, cut expenditures, and begin the process of privatizing the energy sector as well as restructuring the country’s banking sector. The international financial community has been encouraged by these changes and, in late September 2001, the IMF and the World Bank resumed their financing programs for Ukraine by releasing funds that had been on hold since 2000.

Another large FSU economy, Kazakhstan, has also performed well over the past 2 years, with GDP increasing by 9.6 percent in 2000 and 11.6 percent in 2001 [29]. Unlike Ukraine, Kazakhstan is an oil exporter, and much of its growth can be attributed to increased oil production. The government also supported private-sector growth by implementing tax cuts in 2001. With a banking sector that has been privatized and is widely considered to be among the best in the FSU, foreign direct

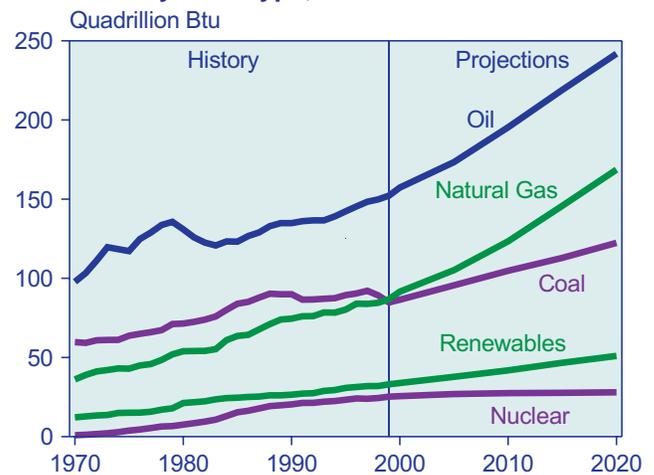
investment has increased strongly over the past few years and is further encouraging the country’s economic growth.

## Outlook for Primary Energy Consumption

The *IEO2002* reference case projects that consumption of every primary energy source will increase over the 21-year forecast horizon (Figure 16). Most of the increment in energy consumption in the reference case is in the form of fossil fuels (oil, natural gas, and coal), because it is expected that fossil fuel prices will remain relatively low, and that the cost of generating energy from non-fossil fuels will not be competitive. It is possible, however, that as environmental programs or government policies—particularly those designed to limit or reduce greenhouse gas emissions—are implemented, the outlook might change, and non-fossil fuels (including nuclear power and renewable energy sources such as hydroelectricity, geothermal, biomass, solar, and wind power) might become more attractive. The *IEO2002* projections assume that government policies or programs in place as of October 1, 2001, will remain constant over the forecast horizon.

Oil is expected to remain the dominant energy fuel throughout the forecast period (maintaining a 40-percent share of total energy use between 1999 and 2020), as it has for decades. In the industrialized world, increases in oil use are projected primarily in the transportation sector, where there are currently no available fuels to compete significantly with oil products. The *IEO2002* reference case projects declining oil use for

**Figure 16. World Energy Consumption by Fuel Type, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

electricity generation, with other fuels (mostly natural gas) expected to be more favorable alternatives to oil-fired generation.

In the developing world, oil consumption is projected to increase for all end uses. In some countries where non-commercial fuels have been widely used in the past (such as fuel wood for cooking and home heating), diesel generators are now sometimes being used to dissuade rural populations from decimating surrounding forests and vegetation, most notably in Sub-Saharan Africa, Central and South America, and Southeast Asia [30]. Because the natural gas infrastructure necessary to expand its use has not been as widely established in the developing world as it has in the industrialized world, natural gas use is expected to grow in the developing world, but not enough to accommodate all of the increase in demand for energy.

Natural gas is projected to be the fastest growing primary energy source worldwide, maintaining growth of 3.2 percent annually over the 1999-2020 period, more than twice the rate of growth for coal use. Natural gas consumption is projected to rise from 84 trillion cubic feet in 1999 to 162 trillion cubic feet in 2020, particularly for electricity generation. Gas is increasingly seen as the desired option for electric power, given the efficiency of combined-cycle gas turbines relative to coal- or oil-fired generation, and the fact that it burns more cleanly than either coal or oil, making it a more attractive choice for countries interested in reducing greenhouse gas emissions.

Coal use worldwide is projected to increase by 2.0 billion short tons (at a rate of 1.7 percent per year) between 1999 and 2020. Substantial declines in coal use are projected for Western Europe and the EE/FSU countries, where natural gas is increasingly being used to fuel new growth in electric power generation, and for other industrial and building sector uses (Figure 17). In the developing world, however, even larger increases in coal use are expected. The largest increases are projected for China and India, where coal supplies are plentiful. Together these two countries account for 85 percent of the projected rise in coal use in the developing world over the forecast period.

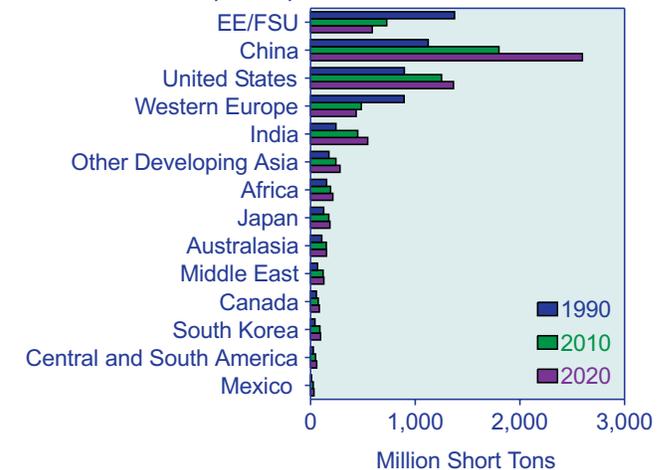
Worldwide, consumption of electricity generated from nuclear power is expected to increase from 2,396 billion kilowatthours in 1999 to 2,667 billion kilowatthours in 2020. Although past editions of this report have projected declines in nuclear electricity consumption toward the end of the forecast horizon, higher capacity utilization and fewer expected retirements of existing plants have resulted in a revision to the expectations for a decline in consumption. Extensions of operating licenses (or the equivalent) for nuclear power plants are expected to be granted among the countries of the

industrialized world, slowing the decline in nuclear generation. In many of the industrialized countries, extending the operating life of a nuclear power plant is a decision left primarily to the owner and thus is an economic decision. In the *IEO2002* reference case, world nuclear capacity is projected to rise from 350 gigawatts in 2000 to 361 gigawatts in 2015 before falling to 359 gigawatts in 2020.

The highest growth in nuclear generation is projected for the developing world, where consumption of electricity from nuclear power is projected to increase by 4.7 percent per year between 1999 and 2020. In particular, developing Asia is expected to see the greatest expansion in new nuclear generating capacity. The nations of developing Asia account for half of the 33 reactors currently under construction worldwide, including 8 in China, 4 in South Korea, 2 in India, and 2 in Taiwan.

Consumption of electricity from hydropower and other renewable energy sources is projected to grow by 2.1 percent annually in the *IEO2002* forecast. With fossil fuel prices projected to remain relatively low in the reference case, renewable energy sources are not expected to be widely competitive, and the renewable share of total energy use is expected to decline from 9 percent in 1999 to 8 percent in 2020. In the developing world, particularly in countries of developing Asia, such as China, India, Malaysia, and Vietnam, much of the growth in renewable energy use is driven by the installation of large-scale hydroelectric power plants. In the industrialized world, nonhydroelectric renewable energy sources are projected to predominate, particularly wind power in Western Europe and biomass and geothermal power in the United States.

**Figure 17. World Coal Consumption by Region, 1990, 2010, and 2020**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, *World Energy Projection System* (2002).

## Outlook for Carbon Dioxide Emissions

If fossil fuel consumption grows to the levels projected in the *IEO2002* reference case, carbon dioxide emissions are expected to rise to 7.9 billion metric tons carbon equivalent in 2010 and to 9.9 billion metric tons by 2020 (Figure 18). Much of the increase is expected in the developing countries, where emerging economies are expected to produce the largest increases in energy consumption, and carbon dioxide emissions are projected to grow by an average of 3.6 percent per year between 1999 and 2020. Developing countries alone account for 77 percent of the projected increment in world carbon emissions between 1990 and 2010 and 72 percent between 1990 and 2020 (Figure 19). Continued heavy reliance on coal and other fossil fuels projected for the developing countries is expected to drive the growth in carbon dioxide emissions over the forecast period.

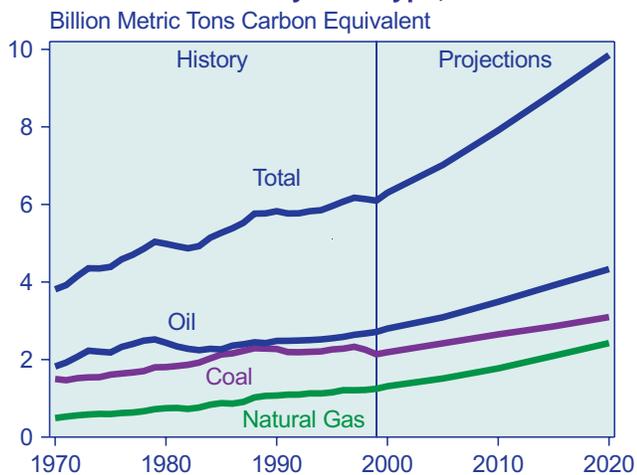
In November 2001, participating member countries of the United Nations' seventh Conference of Parties (COP-7) met in Marrakesh, Morocco, and reached final agreement for the procedures and institutions needed to make the Kyoto Protocol fully operational. Although the

United States was present at COP-6 in Bonn and at COP-7, it did not take an active role in the negotiations. In March 2001, the United States announced that it would not support the Kyoto Protocol. As of March 2002, 83 countries and the European Community had signed the treaty.<sup>2</sup> It was ratified by 51 signatories, only two of which (the Czech Republic and Romania) are among the Annex I countries<sup>3</sup> that would be required to limit or reduce their greenhouse gas emissions relative to 1990 levels under the terms of the Protocol.

On March 4, 2002, the European Union (EU) voted to ratify the Protocol, committing its 15 member countries to reductions in greenhouse gas emissions as specified in the accord [31]. All the EU members are expected to ratify the Kyoto Protocol formally by June 1, 2002. No agreement has been reached among the EU member countries, however, with regard to the individual emission reductions that will be required. Denmark has argued that it was given a disproportionate share of the EU's total reduction burden.

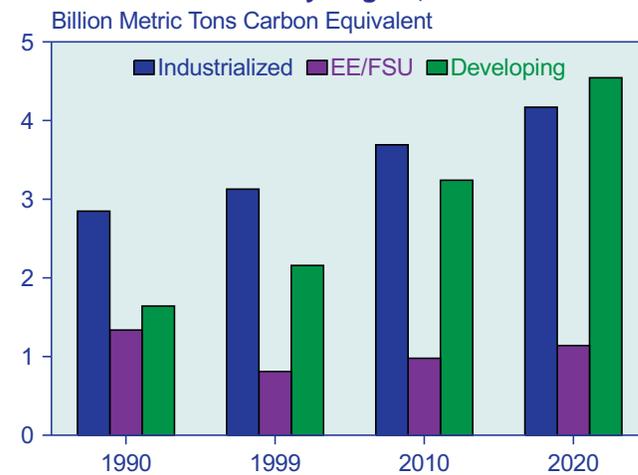
The Kyoto Protocol enters into force 90 days after it has been ratified by at least 55 Parties to the United Nations Framework Climate Change Convention (UNFCCC),

**Figure 18. World Energy-Related Carbon Dioxide Emissions by Fuel Type, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

**Figure 19. World Energy-Related Carbon Dioxide Emissions by Region, 1990-2020**



Sources: **1990 and 1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

<sup>2</sup>The following 51 Parties to the Convention have ratified, accepted, acceded, or approved the Protocol as of March 28, 2002: Antigua and Barbuda, Argentina, Azerbaijan, Bahamas, Bangladesh, Barbados, Benin, Bolivia, Burundi, Colombia, Cook Islands, Cyprus, Czech Republic, Djibouti, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, Fiji, Gambia, Georgia, Guatemala, Guinea, Honduras, Jamaica, Kiribati, Lesotho, Malawi, Maldives, Malta, Mauritius, Mexico, Micronesia, Mongolia, Morocco, Nauru, Nicaragua, Niue, Palau, Panama, Paraguay, Romania, Samoa, Senegal, Trinidad and Tobago, Turkmenistan, Tuvalu, Uganda, Uruguay, Uzbekistan, and Vanuatu.

<sup>3</sup>Turkey and Belarus, which are represented under Annex I of the UNFCCC, do not face quantified emission targets under the Kyoto Protocol. The Kyoto Protocol includes emission targets for 4 countries not listed under Annex I—namely, Croatia, Liechtenstein, Monaco, and Slovenia. Collectively, the 39 Parties facing specific emissions targets under the Kyoto Protocol are commonly referred to as “Annex B Parties,” because their targets were specified in Annex B of the Protocol. In addition, Kazakhstan proposed an amendment to the Marrakesh agreement, requesting that its name be added to the list of Annex I countries.

including a representation of Annex I countries accounting for at least 55 percent of the total 1990 carbon dioxide emissions from the Annex I group. Although the United States had the largest share of Annex I emissions in 1990 at 35 percent, even without U.S. participation the Protocol could enter into force for the other signatories.

Oil consumption is projected to account for the largest increment in worldwide carbon dioxide emissions. In 2020, emissions related to oil use are projected to be 1.9 billion metric tons carbon equivalent higher than the 1990 level. Emissions from natural gas use are expected to be 1.4 billion metric tons above 1990 levels in 2020 and emissions from coal 0.8 billion metric tons above 1990 levels. Although natural gas use is expected to increase at a faster rate than oil use, it is a less carbon-intensive fuel.

If the Kyoto Protocol became effective and the industrialized Annex I countries tried to reduce emissions solely by cutting fossil fuel consumption, reductions in energy use between 30 and 60 quadrillion Btu would be necessary (depending on the mix of fossil fuels used to achieve the reduction because of the relative differences in carbon intensity among the fossil fuels).<sup>4</sup> It is more likely, however, that most countries would attempt to reduce greenhouse gas emissions through alternative strategies, such as fuel switching, conservation measures, reforestation, emissions trading, and others.

Because there were no binding agreements to reduce or limit greenhouse gas emissions at the time this report was prepared, the *IEO2002* reference case projections do not account for the impact of any potential policy. Carbon dioxide emissions in the industrialized Annex I countries alone (i.e., excluding the transitional Annex I countries of the EE/FSU) are projected to grow to 3,527 million metric tons carbon equivalent in 2010 and 3,938 million metric tons in 2020, from 2,765 million metric tons in 1990. Approximately 43 percent of the expected increment is attributed to natural gas consumption, because many of the industrialized Annex I countries are increasingly turning to natural gas for new electricity generation because of its relative efficiency and low carbon dioxide emissions. Total Annex I emissions are projected to grow to 4,359 million metric tons carbon equivalent in 2010 and 4,900 million metric tons in 2020 from 3,897 million metric tons in 1990.

Oil accounts for 44 percent of the projected increase in carbon dioxide emissions in the industrial Annex I countries, which rely heavily on oil for transportation and, at present, have few economical alternatives. Only 12 percent of the projected increase in carbon dioxide emissions for the region are attributed to coal use. Projected

decreases in coal consumption in Western Europe and moderate increases in the other industrialized countries account for coal's smaller portion of rising emissions.

Carbon dioxide emissions fell by 527 million metric tons in the transitional economies of the EE/FSU between 1990 and 1999, from 1,337 million metric tons to 810 million metric tons carbon equivalent. Emissions in the EE/FSU countries are expected to rise to 978 million metric tons carbon equivalent in 2010 and to 1,139 million metric tons in 2020, remaining below their 1990 level even at the end of the forecast horizon.

*IEO2002* projects that the Annex I EE/FSU countries could provide 318 million metric tons of potential emissions allowances for the Annex I emissions reduction effort in 2010. Without allowance trading, the industrialized Annex I countries (including the United States) would have to reduce their emissions by a combined 948 million metric tons (or 27 percent) relative to the reference case projection for 2010. Because the EE/FSU Annex I countries are projected to emit about 318 million metric tons less than their Protocol targets, however, Annex I member countries as a whole would need to reduce their combined emissions by only 630 million metric tons (or 14 percent) in 2010 relative to the baseline projection. Removing the United States from the computations (given the country's announcement that it will not participate in this program), the 318 million metric tons of potential carbon dioxide emissions trading equivalents would mean that the remaining Kyoto Protocol participants would have to reduce their emissions by only 53 million metric tons—2 percent below the *IEO2002* reference case baseline in 2010.

## Alternative Growth Cases

A major source of uncertainty in the *IEO2002* forecast is the expected rate of future economic growth. *IEO2002* includes a high economic growth case and a low economic growth case in addition to the reference case. The reference case projections are based on a set of regional assumptions about economic growth paths—measured by GDP—and energy elasticity (the relationship between changes in energy consumption and changes in GDP). The two alternative growth cases are based on alternative assumptions about possible economic growth paths (Figure 20).

For the high and low economic growth cases, different assumptions are made about the range of possible economic growth rates among the industrial, transitional EE/FSU, and developing economies. For the industrialized countries, one percentage point is added to the reference case GDP growth rates for the high economic

<sup>4</sup>This range was calculated by removing consumption of the most carbon-intensive fuel possible, coal, and the least carbon-intensive fossil fuel possible, natural gas, with the understanding that it probably would be impractical to reduce consumption of coal only, and a combination of fossil fuels would have to be reduced.

growth case and one percentage point is subtracted from the reference case GDP growth rates for the low economic growth case. Outside the industrialized world and excluding China and the EE/FSU, reference case GDP growth rates are increased and decreased by 1.5 percentage points to provide the high and low economic growth case estimates.

Because China experienced particularly high, often double-digit growth in GDP throughout much of the 1990s, it has the potential for a larger downturn in economic growth. In contrast, the EE/FSU region suffered a severe economic collapse in the early part of the decade and has been trying to recover from it with mixed success. The EE/FSU nations have the potential for substantially higher economic growth if their current political and institutional problems moderate sufficiently to allow the recovery of a considerable industrial base. As a result of these uncertainties, 3.0 percentage points are subtracted from the reference case GDP assumptions for China to form the low economic growth case, and 1.5 percentage points are added to the reference case to form the high economic growth case. For the EE/FSU region, 1.5 percentage points are subtracted from the reference case assumptions to derive the low economic growth case, and 3.0 percentage points are added for the high economic growth case.

The *IEO2002* reference case shows total world energy consumption reaching 612 quadrillion Btu in 2020, with the industrialized world projected to consume 278 quadrillion Btu, the transitional EE/FSU countries 73 quadrillion Btu, and the developing world 260 quadrillion Btu. In the high economic growth case, total world

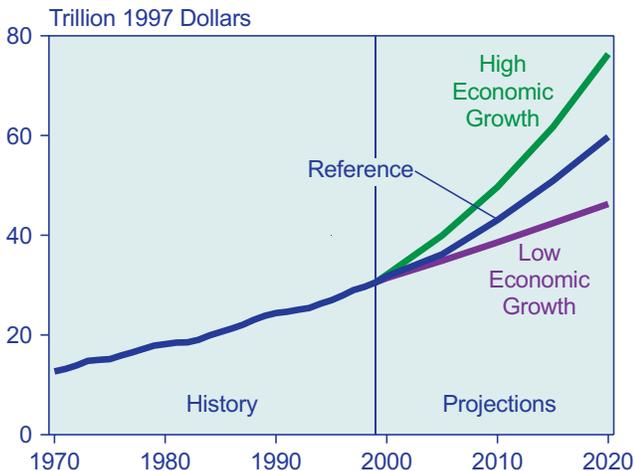
energy use in 2020 is projected to be 728 quadrillion Btu, 117 quadrillion Btu higher than in the reference case (Figure 21). Under the assumptions of the low economic growth case, worldwide energy consumption in 2020 would be 88 quadrillion Btu lower than in the reference case (or 524 quadrillion Btu). Thus, there is a substantial range of 205 quadrillion Btu, or one-third of the total consumption projected for 2020 in the reference case, between the projections in the high and low economic growth cases. Corresponding to the range of the energy consumption forecasts, carbon dioxide emissions in 2020 are projected to total 8,365 million metric tons carbon equivalent in the low economic growth case (1,485 million metric tons less than the reference case projection) and 11,781 million metric tons carbon equivalent in the high economic growth case (1,930 million metric tons higher than the reference case projection).

## Trends in Energy Intensity

Another way of quantifying the uncertainty surrounding a long-term forecast is to consider the relationship of energy use to GDP over time. Economic growth and energy demand are linked, but the strength of that link varies among regions and their stages of economic development. In industrialized countries, history shows the link to be a relatively weak one, with energy demand lagging behind economic growth. In developing countries, demand and economic growth have been more closely correlated in the past, with energy demand growth tending to track the rate of economic expansion.

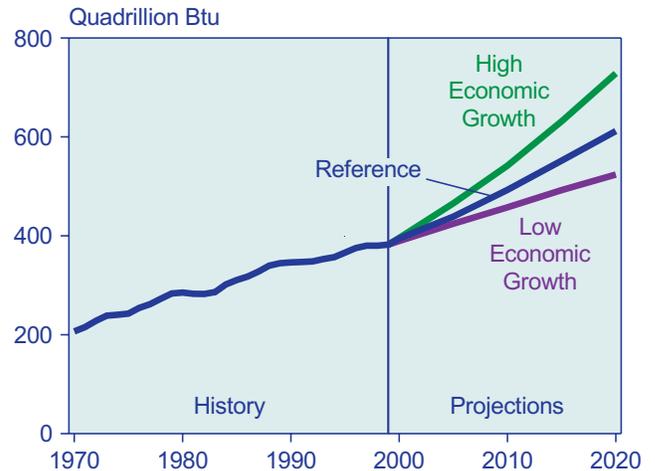
The historical behavior of energy intensity in the FSU is problematic. Since World War II, the EE/FSU economies

**Figure 20. World Gross Domestic Product in Three Economic Growth Cases, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** DRI-WEFA, *World Economic Outlook*, Vol. 1 (Lexington, MA, Third Quarter 2001); and EIA, World Energy Projection System (2002).

**Figure 21. World Energy Consumption in Three Economic Growth Cases, 1970-2020**



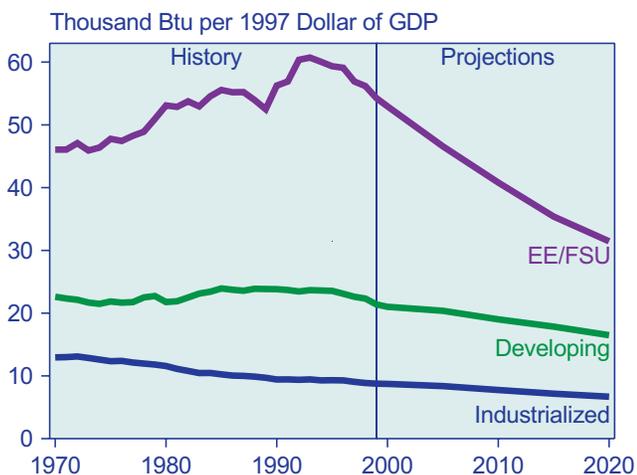
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

have had higher levels of energy intensity than either the industrialized or the developing countries. In the FSU, however, energy consumption grew more quickly than GDP until 1990, when the collapse of the Soviet Union created a situation in which both income and energy use were declining, but GDP fell more quickly and, as a result, energy intensity increased. Over the forecast horizon, energy intensity is expected to decline in the region as the EE/FSU nations continue to recover from the economic and social problems of the early 1990s. Still, energy intensity in the EE/FSU is expected to be almost double that in the developing world and five times that in the industrialized world in 2020 (Figure 22).

The stage of economic development and the standard of living of individuals in a given region strongly influence the link between economic growth and energy demand. Advanced economies with high living standards have relatively high energy use per capita, but they also tend to be economies where per capita energy use is stable or changes very slowly, and increases in energy use tend to correlate with employment and population growth.

In the industrialized countries, there is a high penetration rate of modern appliances and motorized personal transportation equipment. To the extent that spending is directed to energy-consuming goods, it involves more often than not purchases of new equipment to replace old capital stock. The new stock is often more efficient than the equipment it replaces, resulting in a weaker link between income and energy demand. In developing countries, standards of living, while rising, tend to be low relative to those in more advanced economies.

**Figure 22. World Energy Intensity by Region, 1970-2020**



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

Changing growth patterns of energy intensity could have dramatic impacts on energy consumption in the projection period, particularly among the developing countries. For instance, if energy intensities in each of the developing countries are assumed to improve (decline) annually by a percentage equal to the single greatest annual improvement recorded between 1990 and 1999, energy intensity in the developing world as a whole would fall by 69 percent between 1999 and 2020. Historically, the average of the largest single-year improvements in energy intensity for each of the developing nations has been 6 percent, and the single-year improvements for individual developing countries have ranged from 15 percent (China) to 3 percent (Brazil). If energy intensity in each of the developing countries were to improve annually over the forecast period at the highest historical rate of improvement recorded for the country in a single year, their combined energy consumption in 2020 would be 103 quadrillion Btu, as compared with the reference case projection of 260 quadrillion Btu.

If, on the other hand, energy intensity in each of the developing countries were to change annually at the lowest historical rate of improvement (or the highest rate of worsening) recorded for a single year from 1990 to 1999, energy intensity in the developing world as a whole would increase (worsen) by 120 percent between 1999 and 2020. Historically, the average of the largest single-year increases in energy intensity for each of the developing nations (including the smallest historical decreases in countries where energy intensity has improved every year) has been 4 percent, ranging from an increase of 10 percent (South Korea) to a decrease of 4 percent (China). If energy intensity in each of the developing countries were to worsen (increase) annually over the forecast period at the highest historical rate recorded for the country in a single year (or to improve by the lowest rate recorded for countries where energy intensity has improved every year), their combined energy consumption in 2020 would climb to 744 quadrillion Btu in 2020—almost three times the reference case projection.

## Forecast Comparisons

Another way to examine the uncertainty associated with the *IEO2002* projections is to compare them with those offered by other forecasters. Four organizations provide forecasts comparable to those in *IEO2002*. The International Energy Agency (IEA) provides “business as usual” projections to the year 2020 in its *World Energy Outlook 2000*. DRI-WEFA also provides energy forecasts by fuel to 2020 in its *World Energy Service: World Outlook 2000*. Petroleum Economics, Ltd. (PEL) and Petroleum Industry Research Associates (PIRA) publish world energy forecasts to the year 2015. For this comparison, 1997 is used as the base year for all the forecasts, because IEA does not publish data for any other historical years.

Regional breakouts among the forecasting groups vary, complicating the comparisons. For example, *IEO2002* includes Mexico in North America, but all the other forecasts include Mexico in Latin America. As a result, for purposes of this comparison, Mexico has been removed from North America in the *IEO2002* projections and added to Central and South America to form a “Latin America” country grouping that matches the other series. DRI-WEFA and PIRA include only Japan in industrialized Asia, whereas industrialized Asia in the *IEO2002* forecast comprises Japan, Australia, New Zealand, and the U.S. Territories. DRI-WEFA and *IEO2002* include Turkey in the Middle East, but IEA includes Turkey, as well as the Czech Republic, Hungary, and Poland, in “OECD Europe” (which is designated as “Western Europe” for this comparison). PEL also places Turkey in Western Europe but includes the Czech Republic, Hungary, and Poland in Eastern Europe, as does *IEO2002*. Although most of the differences involve fairly small countries, they contribute to the variations among the forecasts.

All the forecasts provide projections out to the year 2010 (Table 2). The growth rates for energy consumption among the reference case forecasts for the 1997-2010 time period are similar, ranging between 2.0 and 2.1 percent per year. All the forecasts for total energy consumption fall well within the range of variation defined by the

*IEO2002* low and high economic growth cases; in fact, all are within a range of 0.1 percentage point around the *IEO2002* reference case.

The regions for which the largest variations are seen among the forecasts are developing Asia, Latin America, and the EE/FSU. For developing Asia the projected average annual growth rates vary by 1.0 percentage point among the forecasts. DRI-WEFA projects the lowest growth in energy demand in the region at 3.1 percent per year between 1997 and 2010. However, DRI-WEFA only reports a projection for all of Asia, and lower expected growth rates in the industrialized countries of that region (i.e., Australia, Japan, and New Zealand) may be dampening the growth expected in the entire region. PEL projects the highest average growth for developing Asia in the 1997-2010 period, at 4.1 percent per year. *IEO2002* expects energy demand in developing Asia to grow by 3.3 percent annually over this time period.

Among the nations of developing Asia, the widest variations in the energy consumption forecasts are seen for China. PEL projects a growth rate of 4.6 percent per year, higher than projected in the *IEO2002* high economic growth case (4.1 percent per year). The *IEO2002* reference case projection for China defines the lower range of the forecasts, at 3.2 percent per year between 1997 and 2010.

**Table 2. Comparison of Energy Consumption Growth Rates by Region, 1997-2010**  
(Average Annual Percent Growth)

Region	<i>IEO2002</i>			<i>IEO2001</i>	DRI-WEFA	IEA	PIRA	PEL
	Low Growth	Reference	High Growth					
<b>Industrialized Countries</b> . . . . .	<b>1.0</b>	<b>1.3</b>	<b>1.6</b>	<b>1.3</b>	<b>1.3</b>	<b>1.2</b>	<b>1.0</b>	<b>1.1</b>
United States and Canada . . . . .	1.4	1.6	1.8	1.5	1.5	1.1	1.3	1.3
Western Europe . . . . .	0.7	1.1	1.5	1.1	1.1	1.3	0.7	0.9
Asia . . . . .	0.3	1.0	1.3	0.8	—	1.1	0.3 <sup>a</sup>	0.5
<b>EE/FSU</b> . . . . .	<b>0.6</b>	<b>1.4</b>	<b>2.0</b>	<b>1.1</b>	<b>1.1</b>	<b>1.4</b>	<b>2.1</b>	<b>0.9</b>
<b>Developing Countries</b> . . . . .	<b>2.4</b>	<b>3.2</b>	<b>4.5</b>	<b>3.2</b>	<b>2.7</b>	<b>3.6</b>	<b>3.6</b>	<b>3.7</b>
Asia . . . . .	2.3	3.3	4.7	3.3	3.1 <sup>c</sup>	3.9	3.6	4.1
China . . . . .	1.5	3.2	4.1	3.2	—	3.6	4.1	4.6
Other Asia <sup>b</sup> . . . . .	3.1	3.4	5.2	3.3	—	4.2	3.3	3.8
Middle East . . . . .	2.1	2.8	3.9	3.0	3.6	2.7	3.4	3.3
Africa . . . . .	1.7	2.4	3.4	2.6	2.5	2.9	2.9	2.8
Latin America . . . . .	2.9	3.6	4.9	3.6	3.7	3.3	2.6	2.8
<b>Total World</b> . . . . .	<b>1.4</b>	<b>2.0</b>	<b>2.8</b>	<b>2.0</b>	<b>2.1</b>	<b>2.1</b>	<b>2.0</b>	<b>1.8</b>

<sup>a</sup>Japan only.

<sup>b</sup>Other Asia includes India and South Korea.

<sup>c</sup>Includes Japan, Australia, and New Zealand.

Sources: *IEO2002*: Energy Information Administration (EIA), World Energy Projection System (2002). *IEO2001*: EIA, *International Energy Outlook 2001*, DOE/EIA-0484(2001) (Washington, DC, March 2001), Table A1, p. 169. *DRI-WEFA*: DRI-WEFA, *World Energy Service: World Outlook 2000* (Lexington, MA, January 2001). *IEA*: International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), pp. 364-418. *PIRA*: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2001), Tables II-4, II-6, and II-7. *PEL*: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2001), Table 1.

The lower projection for China's energy consumption in the *IEO2002* forecast reflects a precipitous drop in energy use in China between 1997 and 1999, the historical year on which the *IEO2002* forecast is based. Consumption in China fell by 13 percent from 1997 to 1999, attributable to a 24-percent (6 quadrillion Btu) reduction in coal use. As a result, while *IEO2002* projects 5.1-percent annual growth in China's energy use between 1999 and 2010, the higher historical level in 1997 results in a lower growth projection for the 1997-2010 period. The other forecasts were based either on 1997 historical data (IEA) or on the expectation that energy use in China would increase between 1997 and 1999 (PIRA, for instance, estimated a 15-percent increase in energy use over the 2-year period).

Projections for the EE/FSU differ by a range of 1.2 percentage points, varying from 0.9 percent annual growth in energy demand between 1997 and 2010 (PEL) to 2.1 percent per year (PIRA). *IEO2002* projects that energy use in the EE/FSU will increase by 1.4 percent per year over the period. Energy consumption growth rates projected by PIRA fall outside the range defined by the *IEO2002* high and low economic growth cases, demonstrating the great uncertainties among the forecasts about how rapidly the economic recovery might progress over the next decade.

Latin America is another region for which large differences among the forecasts are evident. The projected

growth rates for energy demand from 1997 to 2010 range from 2.6 percent per year (PIRA) to 3.7 percent (DRI-WEFA). The *IEO2002* reference case projects a growth rate of 3.6 percent per year for Latin America. Both PEL and PIRA projections fall below the lower bound of 2.9 percent per year defined by the *IEO2002* low economic growth case, reflecting different expectations of how several key economies of the region (notably, Brazil, Argentina, and Venezuela) may fare over the next several years.

*IEO2002*, PIRA, and PEL provide forecasts for energy use in 2015, the end of the PEL and PIRA forecast horizons (Table 3), and their projections for worldwide growth in energy consumption between 1997 and 2015 are similar, ranging from 1.9 percent per year (PEL) to 2.1 percent per year (*IEO2002* and PIRA). Regionally, however, there are some differences in the expectations for growth in energy demand. *IEO2002*, and to an even greater degree, PIRA, expect a much faster pace of recovery for the EE/FSU over the 1997-2015 period (1.5 and 2.2 percent per year, respectively) than does PEL (0.9 percent per year). *IEO2002* and PEL project similar annual growth rates for energy consumption in the countries of Eastern Europe between 1997 and 2015, with most of the variation in the EE/FSU forecasts resulting from their different expectations for the FSU. (PIRA does not publish a separate forecast for Eastern Europe and the FSU.) *IEO2002* expects much more robust recovery for energy use in the FSU, projecting an

**Table 3. Comparison of Energy Consumption Growth Rates by Region, 1997-2015**  
(Average Annual Percent Growth)

Region	<i>IEO2002</i>			<i>IEO2001</i>	PIRA	PEL
	Low Growth	Reference	High Growth			
<b>Industrialized Countries</b> . . . . .	<b>0.9</b>	<b>1.3</b>	<b>1.6</b>	<b>1.2</b>	<b>0.9</b>	<b>0.4</b>
United States and Canada . . . . .	1.3	1.5	1.8	1.4	1.1	1.1
Western Europe . . . . .	0.6	1.0	1.4	1.0	0.7	0.8
Asia . . . . .	0.3	1.0	1.3	0.9	0.5	0.3
<b>EE/FSU</b> . . . . .	<b>0.8</b>	<b>1.5</b>	<b>2.4</b>	<b>1.4</b>	<b>2.2</b>	<b>0.9</b>
Former Soviet Union . . . . .	0.9	1.7	2.5	1.5	—	0.7
Eastern Europe . . . . .	0.5	1.1	2.0	1.2	—	1.5
<b>Developing Countries</b> . . . . .	<b>2.4</b>	<b>3.3</b>	<b>4.6</b>	<b>3.4</b>	<b>3.4</b>	<b>3.5</b>
Asia . . . . .	2.4	3.4	4.8	3.4	3.7	3.9
China . . . . .	1.8	3.6	4.5	3.6	4.1	4.1
Other Asia <sup>a</sup> . . . . .	2.9	3.3	5.0	3.3	3.3	3.6
Middle East . . . . .	2.2	2.9	4.0	3.1	3.2	3.1
Africa . . . . .	1.7	2.5	3.6	2.6	2.9	2.6
Latin America . . . . .	2.8	3.8	4.9	3.7	2.7	2.8
<b>Total World</b> . . . . .	<b>1.5</b>	<b>2.1</b>	<b>2.9</b>	<b>2.1</b>	<b>2.1</b>	<b>1.7</b>

<sup>a</sup>Other Asia includes India and South Korea.

Sources: *IEO2002*: Energy Information Administration (EIA), World Energy Projection System (2002). *IEO2001*: EIA, *International Energy Outlook 2001*, DOE/EIA-0484(2001) (Washington, DC, March 2001), Table A1, p. 169. **PIRA**: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2001), Tables II-4, II-6, and II-7. **PEL**: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2001).

average increase of 1.7 percent per year, than does PEL (0.7 percent per year).

There is also a significant difference among the three forecasts for the industrialized world over the 1997-2015 time period. The expected average annual growth in energy consumption for the industrialized nations ranges from 0.4 percent for PEL to 1.3 percent in the *IEO2002* reference case. The *IEO2002* projections are higher than PEL's and PIRA's for each of the three regions of the industrialized world. Higher expectations for developing Asia in the PEL and PIRA forecasts, however, offset the more pessimistic outlook for the industrialized nations.

*IEO2002*, IEA, and DRI-WEFA provide energy consumption projections for 2020. Table 4 provides a comparison of growth rates between 1997 and 2020 by region for the three forecasts. Again, the expectations for growth in total world energy consumption are similar, ranging from 2.0 percent per year (IEA) to 2.1 percent per year (DRI-WEFA and *IEO2002*). There are also relatively large differences among the forecasts for the EE/FSU, with growth rate projections ranging from 1.3 percent per year (DRI-WEFA) to 1.6 percent per year (IEA), with *IEO2002* at 1.5 percent per year.

There are some differences among the three forecasts for energy demand growth in the industrialized region

from 1997 to 2020. IEA is less optimistic about growth in the United States and Canada (0.9 percent per year) than is DRI-WEFA (1.1 percent per year) or *IEO2002* (1.3 percent per year). DRI-WEFA, however, does not distinguish between industrialized and developing Asia in its forecast, and so it is difficult to assess what the expectations for Australia, Japan, and New Zealand may have meant for the DRI-WEFA industrialized world growth forecasts during this time period. Both *IEO2002* and IEA project that energy demand in Western Europe and the industrialized Asian countries will grow by 1.0 percent per year between 1997 and 2020.

Energy consumption projections for the developing world also vary in the three forecasts. While all three project the lowest growth rates among the developing world to be in Africa, *IEO2002* expects only a 2.5-percent average annual increase in energy consumption in the region, compared with DRI-WEFA's 2.6 percent and IEA's 2.8 percent. For the Middle East, IEA and *IEO2002* project average annual growth of 2.8 percent, whereas DRI-WEFA projects a 3.4-percent average annual increase over the forecast horizon. Both *IEO2002* and IEA also expect the highest growth in energy consumption to occur in developing Asia (including China); however, because Japan, Australia, and New Zealand cannot be disaggregated from DRI-WEFA's Asia consumption forecast, projected growth is dampened (3.0 percent per year).

**Table 4. Comparison of Energy Consumption Growth Rates by Region, 1997-2020**  
(Average Annual Percent Growth)

Region	<i>IEO2002</i>			<i>IEO2001</i>	DRI-WEFA	IEA
	Low Growth	Reference	High Growth			
<b>Industrialized Countries</b> . . . . .	<b>0.9</b>	<b>1.2</b>	<b>1.5</b>	<b>1.1</b>	<b>1.1</b>	<b>0.9</b>
United States and Canada . . . . .	1.2	1.4	1.7	1.3	1.2	0.9
Western Europe . . . . .	0.6	1.0	1.3	1.0	0.9	1.0
Asia . . . . .	0.3	1.0	1.3	0.9	—	1.0
<b>EE/FSU</b> . . . . .	<b>0.8</b>	<b>1.5</b>	<b>2.4</b>	<b>1.4</b>	<b>1.3</b>	<b>1.6</b>
Former Soviet Union . . . . .	0.9	1.6	2.5	1.5	1.4	—
Eastern Europe . . . . .	0.6	1.2	2.1	1.3	0.9	—
<b>Developing Countries</b> . . . . .	<b>2.3</b>	<b>3.3</b>	<b>4.5</b>	<b>3.4</b>	<b>2.7</b>	<b>3.4</b>
Asia . . . . .	2.3	3.4	4.7	3.4	3.0	3.7
China . . . . .	1.8	3.7	4.6	3.7	—	3.4
Other Asia <sup>a</sup> . . . . .	2.7	3.2	4.8	3.2	—	4.0
Middle East . . . . .	2.2	2.8	4.1	3.1	3.4	2.8
Africa . . . . .	1.6	2.5	3.5	2.6	2.6	2.8
Latin America . . . . .	2.6	3.8	4.7	3.7	3.5	3.1
<b>Total World</b> . . . . .	<b>1.4</b>	<b>2.1</b>	<b>2.9</b>	<b>2.1</b>	<b>2.1</b>	<b>2.0</b>

<sup>a</sup>Other Asia includes India and South Korea.

Sources: *IEO2002*: Energy Information Administration (EIA), World Energy Projection System (2002). *IEO2001*: EIA, *International Energy Outlook 2001*, DOE/EIA-0484(2001) (Washington, DC, March 2001), Table A1, p. 169. *DRI-WEFA*: DRI-WEFA, *World Energy Service: World Outlook 2000* (Lexington, MA, January 2001). *IEA*: International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), pp. 364-418.

Finally, the projections vary not only with respect to levels of total energy demand but also with respect to the composition of primary energy inputs. All the forecasts provide energy consumption projections by fuel in 2010 (Table 5). DRI-WEFA does not provide a breakout of nuclear and other sources of electricity generation but instead provides a single forecast for “primary electricity.”

In terms of oil consumption, all the forecasts expect similar growth worldwide between 1997 and 2010. Oil demand is projected to increase by between 1.7 percent per year (PIRA) and 2.1 percent per year (DRI-WEFA and *IEO2002*). All the forecasts expect natural gas use to grow more rapidly than other fuels between 1997 and 2010. *IEO2002* expects slower growth in coal use over the 13-year period than do the other forecasts. *IEO2002* projects a 1.0-percent average annual growth rate for coal use, as compared with a range of 1.5 percent per year (PEL) to 1.8 percent per year (PIRA and DRI-WEFA) in the other forecasts.

*IEO2002* is more optimistic about the prospects for nuclear electricity generation, projecting average growth of 1.1 percent per year between 1997 and 2010, as compared with the range of 0.6 percent per year (PEL) to 0.8 percent per year (IEA and PIRA) projected in the other forecasts. This optimism reflects the expectations that nuclear generators in the United States and other parts of the industrialized world and in the EE/FSU will not be retired as quickly as expected in prior outlooks.

PEL, PIRA, and *IEO2002* provide world energy consumption projections by fuel for 2015 (Table 6). The three forecasts reflect different views about expected growth by fuel between 1997 and 2015. *IEO2002* expects strong growth in natural gas use to result in slow growth in coal consumption, particularly for electric power generation. PEL expects natural gas use to grow more slowly and coal use to grow more rapidly than projected in *IEO2002*. PIRA expects faster growth in natural gas and coal use but slower growth for nuclear power and renewables than projected in *IEO2002*. Moreover,

**Table 5. Comparison of World Energy Consumption Growth Rates by Fuel, 1997-2010**  
(Average Annual Percent Growth)

Fuel	<i>IEO2002</i>			<i>IEO2001</i>	DRI-WEFA	IEA	PIRA	PEL
	Low Growth	Reference	High Growth					
Oil .....	1.6	2.1	2.9	2.1	2.1	2.0	1.7	1.6
Natural Gas .....	2.5	3.0	3.8	3.1	3.4	2.8	3.4	1.5
Coal .....	0.2	1.0	1.7	0.8	1.8	1.7	1.8	2.9
Nuclear .....	0.7	1.1	1.5	1.0	— <sup>a</sup>	0.8	0.8	1.9
Renewable/Other .....	1.6	2.1	2.9	2.2	— <sup>a</sup>	2.5	1.8	0.6
<b>Total .....</b>	<b>1.4</b>	<b>2.0</b>	<b>2.8</b>	<b>2.0</b>	<b>2.1</b>	<b>2.1</b>	<b>2.0</b>	<b>1.8</b>
Primary Electricity .....	1.2	1.7	2.3	1.7	1.5	1.5	1.3	1.3

<sup>a</sup>DRI-WEFA reports nuclear and hydroelectric power together as “primary electricity.”

Sources: *IEO2002*: Energy Information Administration (EIA), World Energy Projection System (2002). *IEO2001*: EIA, *International Energy Outlook 2001*, DOE/EIA-0484(2001) (Washington, DC, March 2001), Table A1, p. 169. **DRI-WEFA**: DRI-WEFA, *World Energy Service: World Outlook 2000* (Lexington, MA, January 2001). **IEA**: International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), pp. 364-418. **PIRA**: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2001), Table II-8. **PEL**: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2001).

**Table 6. Comparison of World Energy Consumption Growth Rates by Fuel, 1997-2015**  
(Average Annual Percent Growth)

Fuel	<i>IEO2002</i>			<i>IEO2001</i>	PIRA	PEL
	Low Growth	Reference	High Growth			
Oil .....	1.6	2.2	3.0	2.2	1.7	1.7
Natural Gas .....	2.5	3.1	3.9	3.1	3.4	1.3
Coal .....	0.3	1.1	1.9	1.0	1.8	2.7
Nuclear .....	0.4	0.8	1.2	0.8	0.6	1.8
Renewable/Other .....	1.5	2.1	2.9	2.1	1.9	0.2
<b>Total .....</b>	<b>1.5</b>	<b>2.1</b>	<b>2.9</b>	<b>2.1</b>	<b>2.1</b>	<b>1.7</b>
Primary Electricity .....	1.0	1.6	2.2	1.6	1.3	1.3

Sources: *IEO2002*: Energy Information Administration (EIA), World Energy Projection System (2002). *IEO2001*: EIA, *International Energy Outlook 2001*, DOE/EIA-0484(2001) (Washington, DC, March 2001), Table A1, p. 169. **PIRA**: PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2001), Table II-8. **PEL**: Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, June 2001).

*IEO2002* projects much higher growth in nuclear power use (0.8 percent per year) than does PEL (0.2 percent per year).

*IEO2002*, IEA, and DRI-WEFA are the only forecasts that provide projections for 2020 (Table 7). The three forecasts show similar expectations for growth in oil and natural gas use but different expectations for coal and nuclear power. In the *IEO2002* reference case, coal use is projected to increase by 1.2 percent per year, whereas

the IEA and DRI-WEFA projections are considerably higher, at 1.7 and 1.9 percent per year, respectively. Much of the future coal use in the *IEO2002* projection is offset by a more robust forecast for nuclear power than in either of the other two forecasts. *IEO2002* expects primary electricity use (nuclear power and renewable energy) to increase by 1.5 percent per year, compared with 1.0 percent per year in the IEA and DRI-WEFA forecasts.

**Table 7. Comparison of World Energy Consumption Growth Rates by Fuel, 1997-2020**  
(Average Annual Percent Growth)

Fuel	IEO2002			IEO2001	DRI-WEFA	IEA
	Low Growth	Reference	High Growth			
Oil . . . . .	1.5	2.1	3.0	2.2	2.1	1.9
Natural Gas . . . . .	2.5	3.1	3.9	3.1	3.2	2.7
Coal . . . . .	0.3	1.2	2.0	1.0	1.9	1.7
Nuclear . . . . .	0.2	0.7	1.1	0.5	— <sup>a</sup>	0.0
Renewable/Other . . . . .	1.3	2.1	2.8	2.0	— <sup>a</sup>	2.3
<b>Total . . . . .</b>	<b>1.4</b>	<b>2.1</b>	<b>2.9</b>	<b>2.1</b>	<b>2.1</b>	<b>2.0</b>
Primary Electricity . . . . .	0.9	1.5	2.1	1.4	1.0	1.0

<sup>a</sup>DRI-WEFA reports nuclear and hydroelectric power together as “primary electricity.”

Sources: **IEO2002**: Energy Information Administration (EIA), World Energy Projection System (2002). **IEO2001**: EIA, *International Energy Outlook 2001*, DOE/EIA-0484(2001) (Washington, DC, March 2001), Table A1, p. 169. **DRI-WEFA**: DRI-WEFA, *World Energy Service: World Outlook 2000* (Lexington, MA, January 2001). **IEA**: International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), pp. 364-418.

## References

1. Energy Information Administration, *Short-Term Energy Outlook*, November web edition (November 6, 2001), web site [www.eia.doe.gov](http://www.eia.doe.gov).
2. “Oil Prices Sink After OPEC Dithers,” Reuters News Service (November 15, 2001), web site [www.msnbc.com](http://www.msnbc.com).
3. Cambridge Energy Research Associates, “Signs of an OPEC and Non-OPEC Truce,” *CERA Alert* (Cambridge, MA, December 6, 2001), p. 1.
4. D. Rohlfs and N. Sharushkina, “Mousetrap: Russia Readies for Price War with OPEC,” *NEFTE Compass*, Vol. 10, No. 48 (November 29, 2001), p. 6.
5. “Russia To Cut Oil Exports,” *The New York Times Web Edition* (December 5, 2001), web site [www.nytimes.com](http://www.nytimes.com).
6. Energy Information Administration, *Short-Term Energy Outlook* (March 2002) web site [www.eia.doe.gov/steo/pub/contents.html](http://www.eia.doe.gov/steo/pub/contents.html).
7. P. Kiernan, “Crude Trades Sideways; OPEC Yet To Get Supply Cut Pledge from Russia,” *The Oil Daily*, Vol. 52, No. 42 (March 5, 2002), p. 3.
8. R.W. Stevenson, “Economists Make It Official: U.S. Is in Recession,” *The New York Times* (November 27, 2001), p. C1.
9. T. Lee and D. Ryan, “Asia Economic Summary: Fourth Quarter 2001,” *DRI-WEFA, Asia Economic Outlook, Fourth Quarter 2001* (Eddystone, PA, November 5, 2001), p. EX.1.
10. D. Ryan, “Japan: Outlook,” *DRI-WEFA, Asia Economic Outlook, Fourth Quarter 2001* (Eddystone, PA, November 2001), p. JA.4-6.
11. European Central Bank, “Monetary Policy Decisions,” Press Release (September 17, 2001), web site [www.ecb.int](http://www.ecb.int).
12. “Germany Edges Towards Recession,” DRI-WEFA Economic Briefings (November 22, 2001), web site [www.dri-wefa.com](http://www.dri-wefa.com).
13. “French Growth Stronger Than Expected in Third Quarter,” DRI-WEFA Economic Briefings (November 23, 2001), web site [www.dri-wefa.com](http://www.dri-wefa.com).
14. A. Stockman, “United Kingdom: Short-Term Economic Growth,” *DRI-WEFA, Industrialized Countries Monthly Monitor* (Eddystone, PA, October 2001), p. UK.90.
15. T. Lee and D. Ryan, “Asia Executive Summary,” *DRI-WEFA, Asia Economic Outlook, Fourth Quarter 2001* (Eddystone, PA, November 2001), p. EX.1.

16. T. Lee and D. Ryan, "Asia Executive Summary," *DRI-WEFA, Asia Economic Outlook, Fourth Quarter 2001* (Eddystone, PA, November 2001), p. EX.1.
17. T. Lee, "China: Outlook," *DRI-WEFA, Asia Economic Outlook, Fourth Quarter 2001* (Eddystone, PA, November 2001), p. CH.4-5.
18. "China's WTO Membership: A Great Gamble Beijing Cannot Refuse," DRI-WEFA Economic Briefing (November 16, 2001), web site [www.dri-wefa.com](http://www.dri-wefa.com).
19. J. Narasimhan, "India: Outlook and Recent Developments," *DRI-WEFA, Asia Economic Outlook, Fourth Quarter 2001* (Eddystone, PA, November 2001), p. ID.4-5.
20. P. Gall, "Brazil's Natural Gas Market Simultaneously Beckons, Threatens," *The Oil Daily*, Vol. 51, No. 169 (August 31, 2001), p. 4.
21. DRI-WEFA, *Latin American Monthly Monitor* (Eddystone, PA, November 2001), p. iv.
22. DRI-WEFA, *Latin American Monthly Monitor* (Eddystone, PA, November 2001), p. BZ.2.
23. International Monetary Fund, "IMF Augments Argentina Stand-By Credit to \$21.57 Billion, and Completes Fourth Review," Press Release No. 01/37 (September 7, 2001).
24. "Argentines Fear Economic Crisis," *The New York Times Web Edition* (December 10, 2001), web site [www.nytimes.com](http://www.nytimes.com).
25. "Argentina Devalues Currency and Defaults on Its Debts," MSNBC News (January 3, 2001), web site [www.msnbc.com](http://www.msnbc.com).
26. K. Crane, "The CIS: Is Growth Here To Stay?," *PlanEcon Review and Outlook for the Former Soviet Republic* (Washington, DC, October 2001), p. i.
27. K. Crane, "The CIS: Is Growth Here To Stay?," *PlanEcon Review and Outlook for the Former Soviet Republic* (Washington, DC, October 2001), p. vii.
28. Z. Tabernacki, "Outlook for Ukraine," *PlanEcon Review and Outlook for the Former Soviet Republic* (Washington, DC, October 2001), p. 31-33.
29. K. Crane, "Outlook for Kazakhstan," *PlanEcon Review and Outlook for the Former Soviet Republic* (Washington, DC, October 2001), p. 73-75.
30. D.F. Barnes et al., "Tackling the Rural Energy Problem in Developing Countries," *Finance & Development*, Vol. 34, No. 2 (June 1997), pp. 11-15.
31. "EU Ministers Push Kyoto Pact Forward: Agree to Speedy Ratification, But Not on Pollution Limits," *The Toronto Star* (March 4, 2002), web site [www.thestar.com](http://www.thestar.com).